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In-Flight Instrumentation and Launch System for Anti-Personnel Grenades

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13. ABSTRACT *(Maximum 200 words)*

Modem artillery projectiles often carry submunitions. The flight behavior of these submunitions once released from the projectile carrier are often poorly known. A program was conducted to measure the spin of an M42 anti-personnel grenade. A launcher system was assembled using a modified 4.2-inch mortar tube mounted to a 105mm howitzer carriage. A sabot/pusher and charge system were developed. An instrumentation and telemetry system was developed and three units were fabricated. Improper functioning of the howitzer/mortar firing mechanism produced delays in the firing sequence and batteries discharged prior to firing. Hence, no data were received. Subsequently, problems with the firing mechanism have been corrected. Additionally, rechargeable batteries have been procured and will allow for unusual test sequences or occurrences. New circuit devices and assembly procedures have also been established. These instrumentation procedures could be applied to most types of small bursting submunitions.

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1. INTRODUCTION

Projectile flight behavior is normally characterized by a number of techniques such as full range flights supported by tracking radars, spark range aerodynamic tests (Rogers 1958), and yawsonde tests (Mermagen and Clay 1974). Standard instrumentation techniques and procedures exist for testing spin or fin-stabilized projectiles of various calibers. However, modern projectiles often carry submunition systems. Since these submunitions are ejected from the carrier, the aeroballistic behavior of the submunition is often of interest. Trajectory estimates and fuzing issues are related to aeroballistic performance of the submunition. Since these submunitions are small and have unusual shapes, unique launch systems and instrumentation techniques must be developed to provide in-flight data. This report documents an effort to build a launch system (launcher, sabot, pusher, and charge) and to equip an M42 anti-personnel submunition with yawsonde-type technology. This system was designed to obtain spin histories along a flight path that would be similar to those that occur after ejection from a spinning artillery projectile, such as the M483A1 or the M864.

2. BACKGROUND

Typically when detailed flight behavior is required for a spin-stabilized artillery projectile, a yawsonde is employed. Yawsondes are built by the U.S. Army Research Laboratory (ARL) in the configuration of a standard artillery fuze, and they employ two optical sensors that use the sun as a reference. Information from one sensor is easily converted into spin, while a data from the second sensor is combined with the first to obtain yaw. The yawsonde has conditioning electronics, a transmitter/antenna, and a power supply. The volume available within a standard fuze is sufficiently large that commercially available sensors and components can be incorporated into a reliable package. On many occasions a fuze-configured yawsonde cannot be used due to space or the character of the motion. The ratio of the spin and yaw frequencies of the projectile determines how many sightings of the sun must be made to sufficiently describe the yawing motion. Normally, if the ratio between the spin and yaw frequencies is 10 to 1, then sampling theory and practical experience have shown that the yawing motion is accurately traced in both amplitude and frequency. If the vehicle

dynamics are such that this ratio is substantially less than 10 to 1, then multiple sensor systems must be utilized. Such a program was conducted during the development of the SADARM (Seek And Destroy Armor) submunition. This munition is ejected from a projectile and deploys a parachute. During parachute decent, SADARM scans the battlefield for targets. The SADARM motion was measured by a special purpose yawsonde system where eight optical sensors were utilized (Oskay and Mermagen 1981).

3. ROLL SENSOR PACKAGE FOR AN M42 ANTI-PERSONNEL GRENADE

The M42 submunition is shown in Figure 1. It is of substantially smaller volume than a ARL fuze-configured yawsonde, shown with components in Figure 2. The solar sensors, antenna, and power supply systems must be specially configured to instrument an M42 grenade. A new optical sensor was devised by using a miniature infrared sensor with a mask. The sensor had a 20 degree conical field of view and was mounted such that the spinning motion of the grenade would allow the sensor to alternately scan the sky and ground. This changing background for the sensor would produce a sinusoidal signal from the sensor whose frequency was proportional to the spin rate. The sensor and associated circuit outputs were tailored to produce acceptable signal levels for a 250 MHz telemetry system. A simplified schematic of the electronic design is shown in Figure 3. In principle, a higher transmitter frequency should be used so that a much smaller antenna could be designed. This was not possible, since the higher frequency transmitters are presently only available in circular cylindrical cans of approximately 4 cm in diameter and 3 cm in height, clearly far too large for use with an M42. In contrast, the 250 MHz transmitter typically used in a fuze-configured yawsonde is approximately .3 cm by 4 cm by 2 cm. All components and associated electronics were located within the volume that normally holds the shaped charge warhead and fuze. A spiral antenna was then coiled along the exterior surface of the warhead liner. Silver oxide batteries (not a rechargeable type and similar to a hearing aid or watch battery) were used for power. Often rechargeable nickel cadmium (NiCad) batteries are used in telemetry applications. A source for such a miniature NiCad battery could not be located in the desired time frame. In addition to not being rechargeable, silver oxide batteries have other drawbacks. Once

they are installed, their shelf life is uncertain and small current leaks can drain the battery. The flight tests were conducted shortly after assembly. Three such units were built for flight tests. The components used for the M42 could be used for other grenade submunitions such as the the XM80 and a grenade of German design.

4. DEVELOPMENT OF LAUNCHER, SABOT, AND CHARGE SYSTEM

It was necessary to develop a launcher system (mount, tube, charge and sabot). Given that perhaps three grenades (all of different diameter, one being larger than 40mm in diameter) would be tested, a system was selected to accommodate the largest grenade. Initially an air gun was used. This device had been constructed by personnel at the Edgewood Research, Development, and Engineering Center (ERDEC) for launching submunition-type payloads. Two versions of this air pressurized breach and spinning tube launcher presently exist. However during the time frame of the M42 project, only the smaller air gun was available. A sabot/pusher system was fabricated, and several slugs were fired. Sufficiently high launch velocities could not attained, and damage was sustained to the air gun even at low velocities. The small air gun was not felt to be a viable system, and it was decided to develop a more conventional powder launcher rather than wait for the completion of the larger air gun system.

A 4.2-inch mortar tube was then mounted to a 105mm pack howitzer, as shown in Figures 4 and 5. A horizontal firing mechanism was developed for the mortar. Hardware and charges for 4.2-inch mortars are readily available and could be tailored to the specific needs of any of the grenades under consideration. A new sabot/pusher system (shown in Figures 6 and 7) was designed and successfully tested.

5. TEST RESULTS AND PROGRESS

Three M42 grenades were prepared for testing. The instrumented grenades were turned-on, mounted into the sabot and cartridge, and loaded into the launcher. Unfortunately, problems occurred with the firing mechanism. Misfires were experienced with long time delays between shots. Since the units were powered-up and were designed for a normal firing sequence and a short flight, the batteries did

not have sufficient life given lengthy misfire delays. No data were received. Fabrication and testing of more instrumented M42 units was terminated since the initial funding had been expended. At this point several issues needed resolution.

1. improved firing mechanism,

2. miniature NiCad batteries,

3. smaller components, and

4. improved antenna for 250 MHz transmitter.

The failure mode of the firing mechanism was identified, and it has been modified and successfully tested. Additionally, a source of miniature, rechargeable NiCad batteries has been identified and several battery sets were procured.

Smaller components would provide a more reliable instrumentation package, and they would also reduce assembly time. Smaller components are available through the use of surface mount (SM) technology. Surface mount technology is so named since the common electrical components (resistors, capacitors, voltage regulators, operational amplifiers, etc.) are manufactured without traditional electrical leads. Also, the large leads require bulky solder connections. The SM components have small solder tabs underneath each device. This allows for the direct placement of components on the surface of a printed circuit board. After SM components are properly located, the printed circuit board is placed in an IR/convection oven, where the solder will heat and flow to make efficient electrical contacts. Typically, surface mount components are 1/2 to 1/10 the size of the standard components. Additionally, SM components can be placed on both sides of a printed circuit board, providing an even higher packing density.

Another improvement would involve the use of flexible printed circuit boards. Typically, printed circuit boards are rigid so that components with leads can be mounted and soldered. With the advent of SM devices, flexible circuit boards have been developed. Flexible material does not require surface etching with chemicals. In fact, the one method of tracing circuit paths uses a scrolling printer-like system where

a sharp knife simply scrapes away unwanted metallic cladding. This device is driven by a personal computer, so that controlled low rate production is efficient. Also, this methodology is ideal for the fabrication of surface antennas.

A resonant antenna for a 250 MHz transmitter should be relatively easy to fabricate using a 1/2 or 1/4 wave length matching. The standard fuze-configured yawsonde uses a spiral coil. Such an antenna has been fabricated using flexible printed circuit board material and the scrolling cutter. The antenna is much simpler to make and install than the original ones used in the first M42 test series. This new antenna is also of higher gain, and it is shown with other second generation components within Figure 8.

6. CONCLUSIONS

A program was designed to measure the spin of an M42 anti-personnel grenade. A launcher system was assembled using a modified 4.2-inch mortar tube. A sabot/pusher and charge system were also developed. An instrumentation/telemetry system was developed, and three units were fabricated. Improper functioning of the howitzer firing mechanism produced delays in the firing sequence, and batteries discharged prior to firing. Hence, no data were received. Subsequently, problems with the firing mechanism have been corrected. A source of rechargeable batteries has been identified. Additionally, new circuit components and assembly procedures are available for such miniature systems, leading to higher space utility, system reliability, and ease of assembly. These techniques could be applied to small submunitions.

Figure 1. M42 Subminition Showing Cut-away Views.

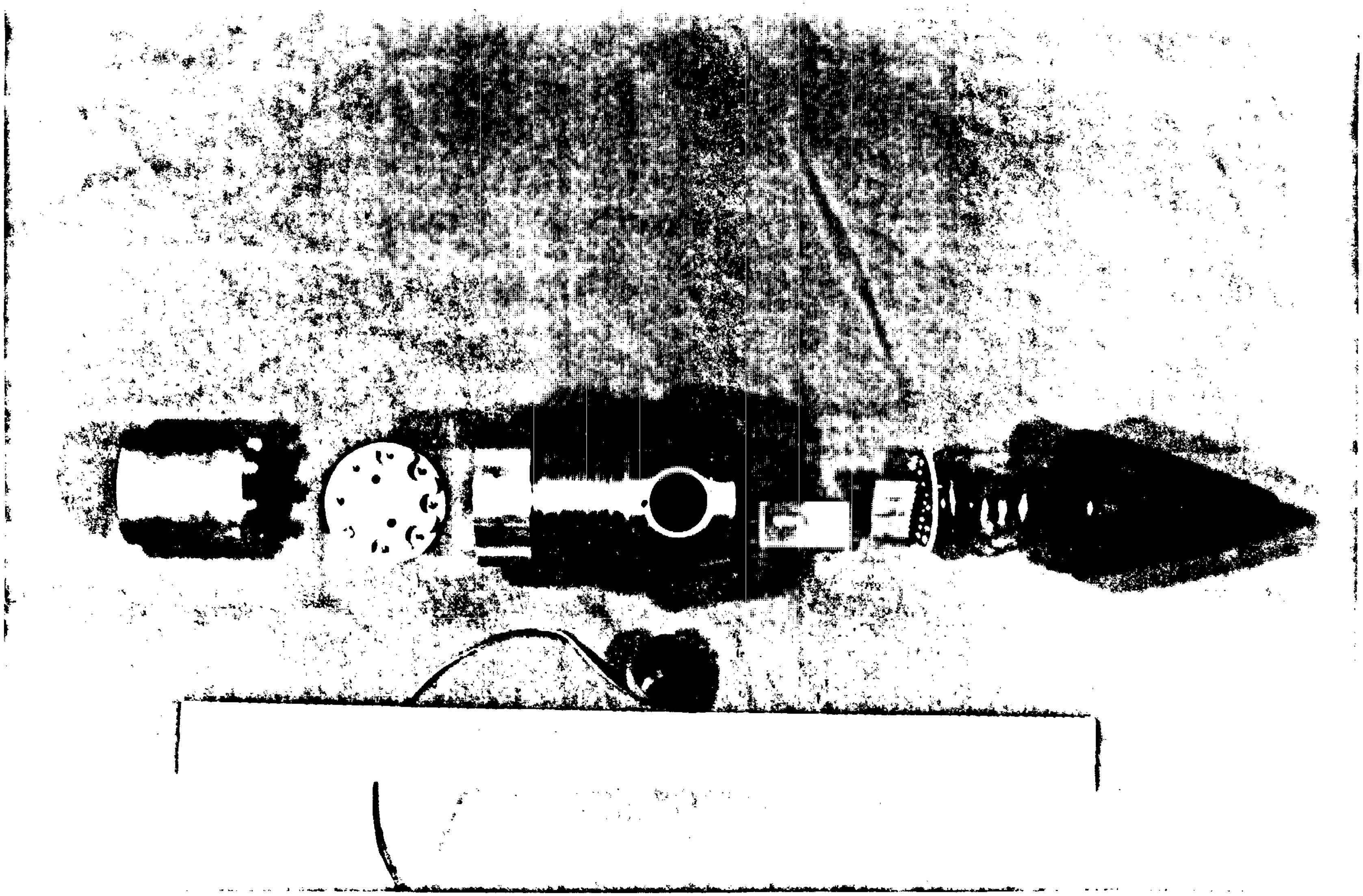

Figure 2 BRL Fuze Configured Yawsonde With Components

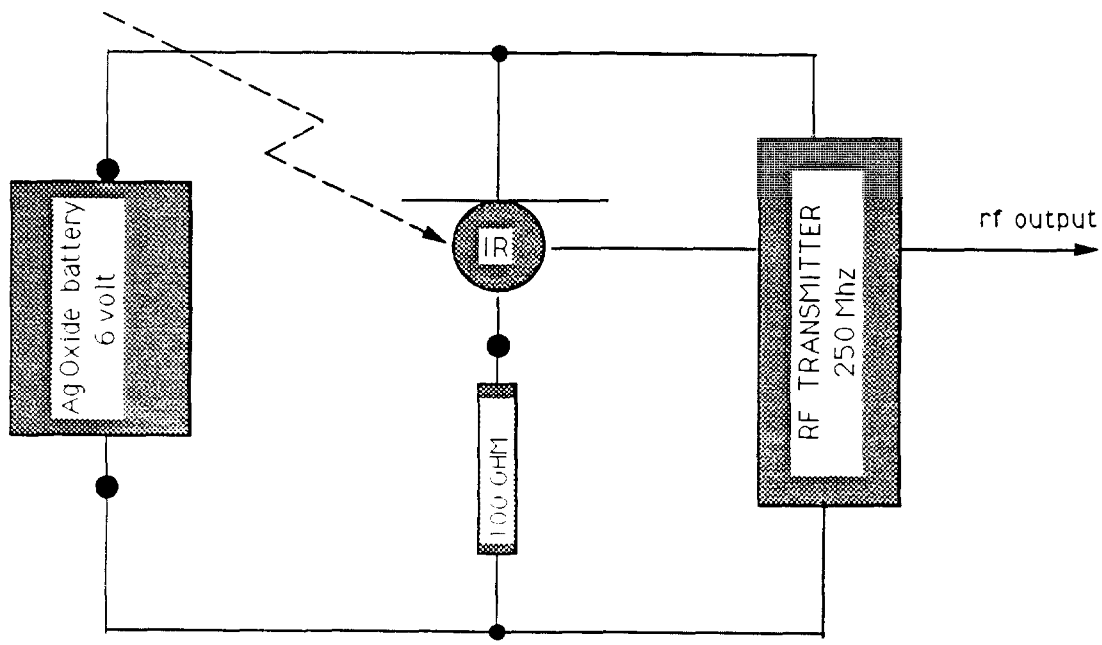

Figure 3. Simplified Schematic of the Roll Sensor for an M42 Grenade.

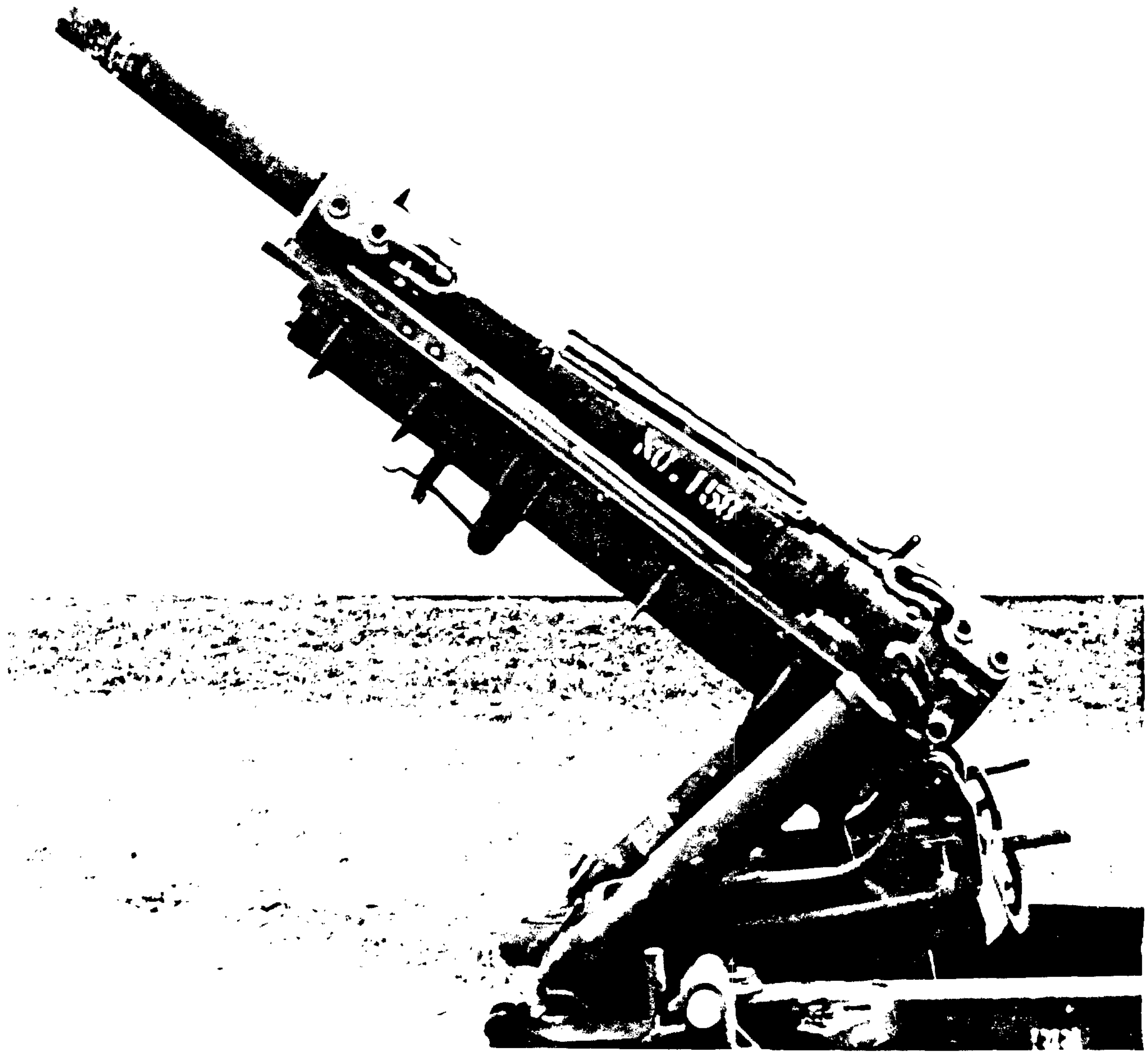

Figure 4 105-mm Howitzer With a Specially Mounted 4.2-Inch Mortar

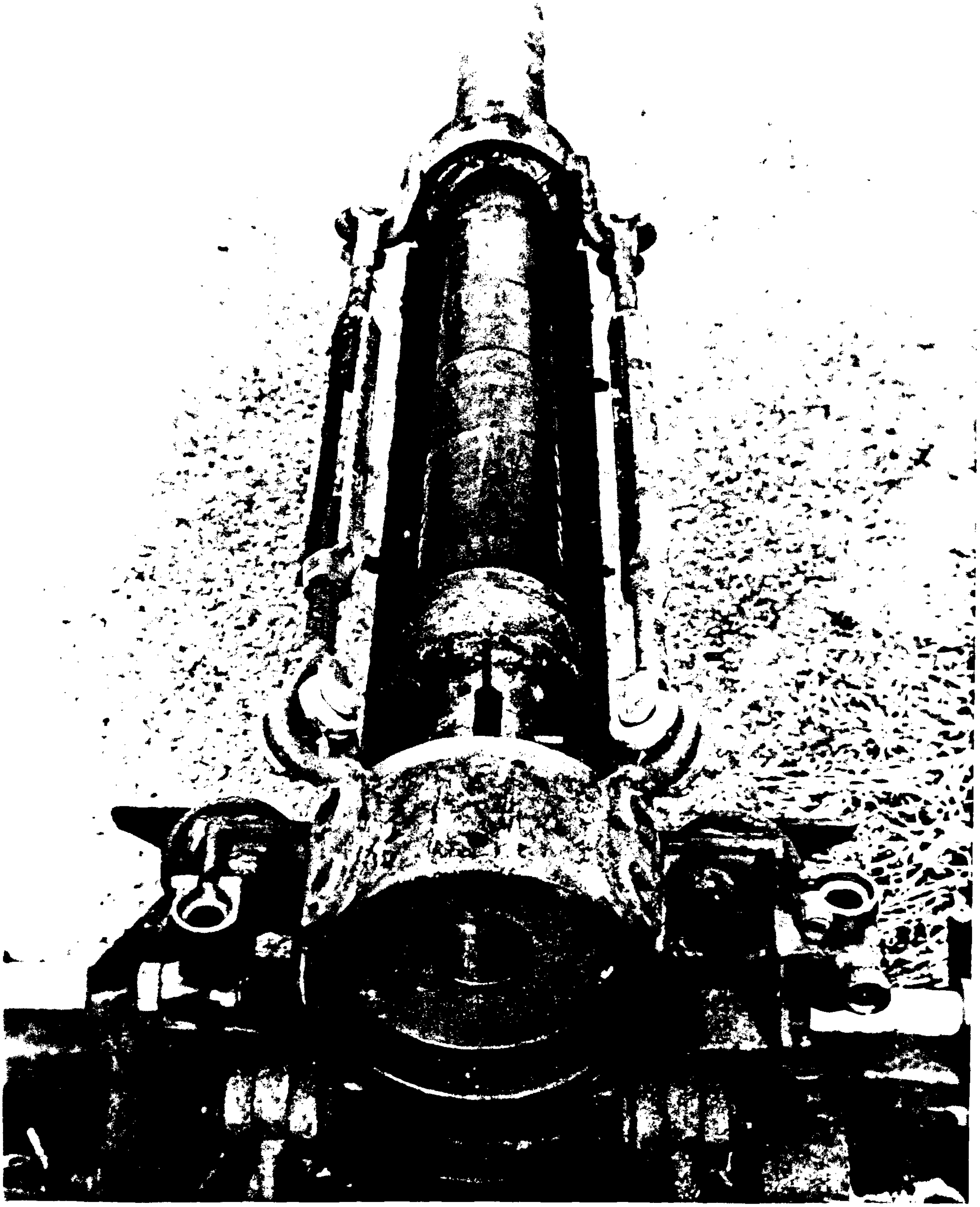

Figure 5. Close-up View of 105-mm Howitzer/4.2-in Mortar Launch System.

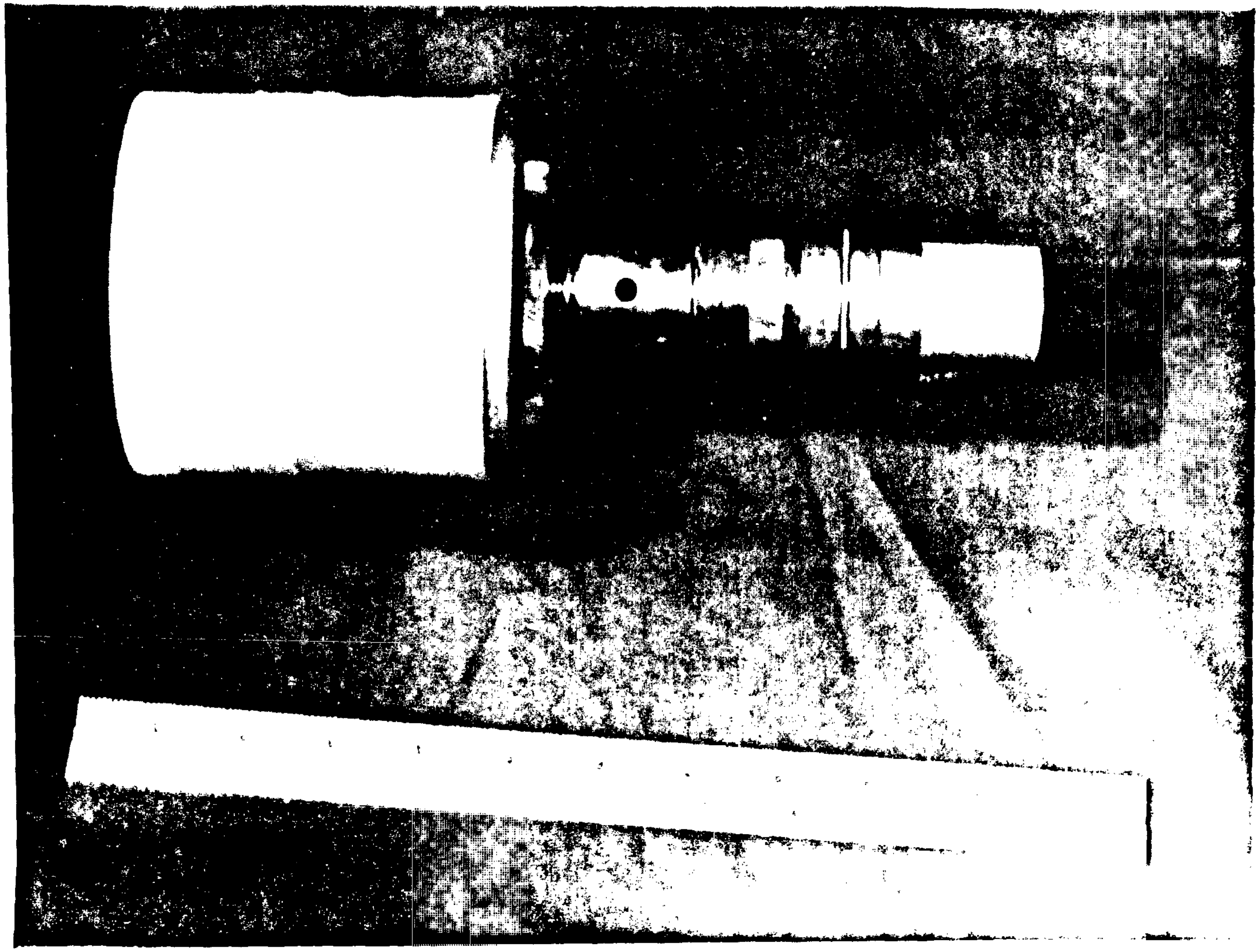

Figure 6. Sabot/Pusher System, Assembled View

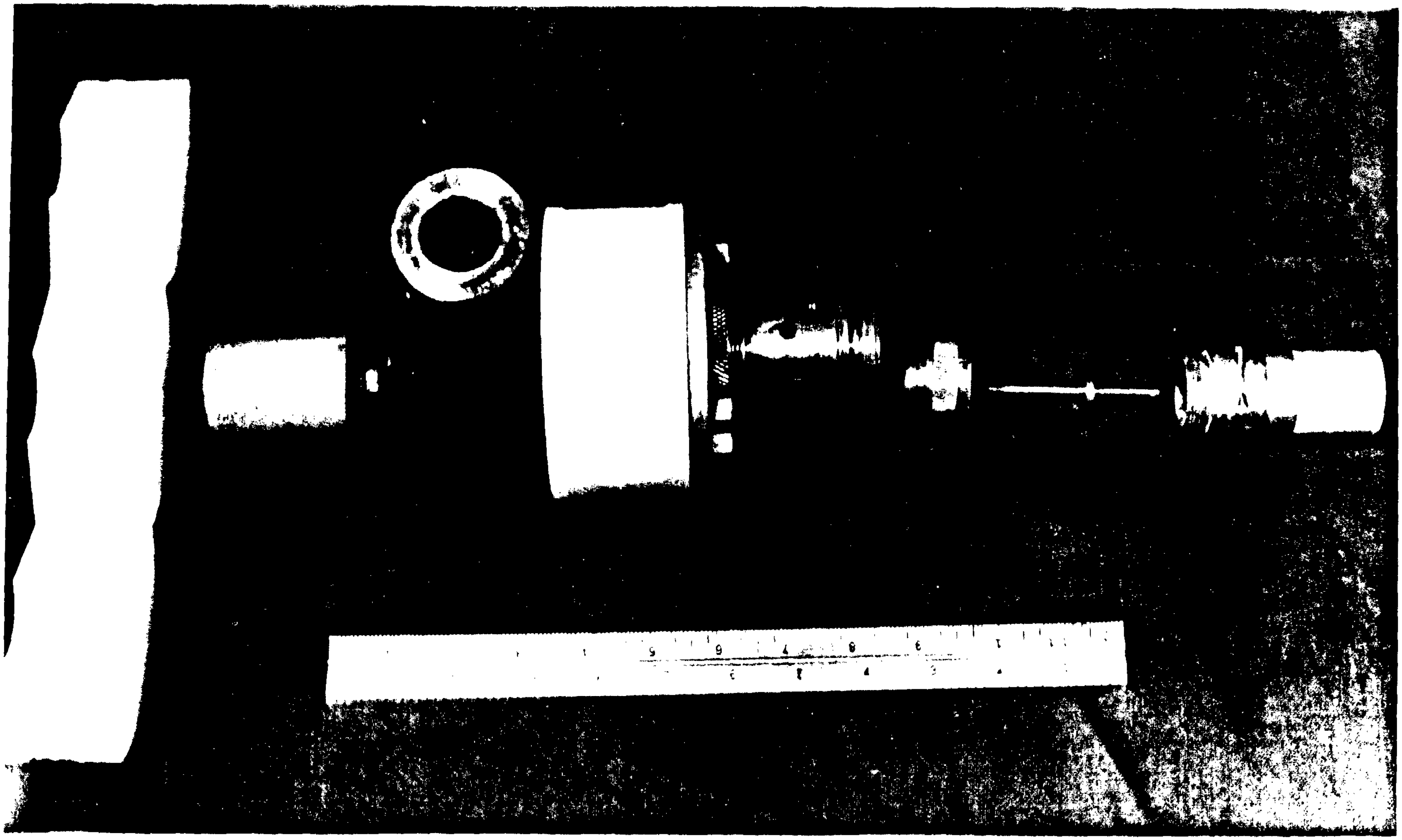

Figure 7. Sabot/Pusher System, Unassembled View

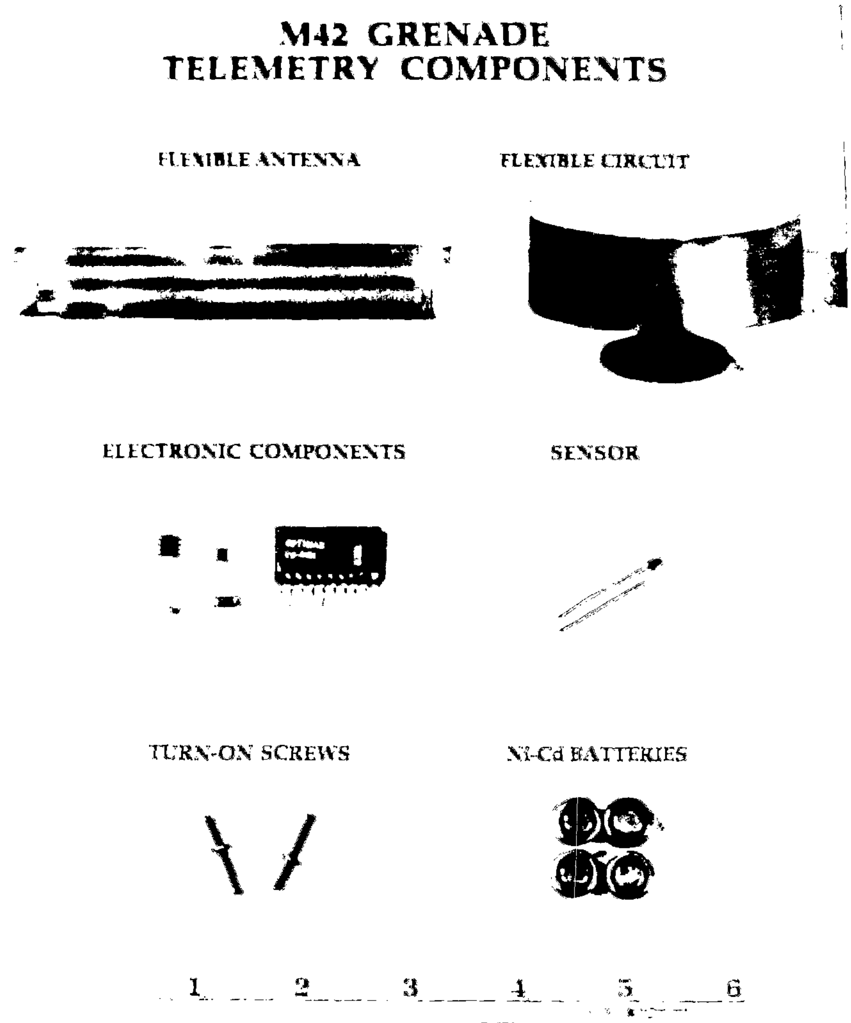

Figure 8. Telemetry Components for Second Generation Grenade Tests.

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